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Observed Parent Behaviors as Time-Varying Moderators of Problem Behaviors Following Traumatic Brain Injury in Young Children

Amery Treble-Barna¹, Huaiyu Zang¹, Nanhua Zhang¹, H. Gerry Taylor², Terry Stancin³, Keith Owen Yeates⁴, and Shari L. Wade¹

¹Cincinnati Children's Hospital Medical Center

²Rainbow Babies and Children's Hospital

³Case Western Reserve University School of Medicine

⁴University of Calgary

Abstract

Parent behaviors moderate the adverse consequences of pediatric traumatic brain injury (TBI); however, it is unknown how these moderating effects change over time. This study examined the moderating effect of observed parent behaviors over time since injury on the relation between TBI and behavioral outcomes. Participants included children, ages 3–7 years, hospitalized for moderate ($n = 52$) or severe ($n = 20$) TBI or orthopedic injury (OI; $n = 95$). Parent–child dyads were videotaped during structured task and free play conditions and parents completed child behavior ratings. Linear mixed models using a lagged, time-varying moderator analysis examined the relationship of observed parent behaviors at the baseline, 6-month, and 12-month assessments to child behavior problems at 6 months, 12 months, and 18 months post injury, after controlling for pre-injury levels of child behavior problems. The effect of TBI on behavior was exacerbated by less favorable parent behaviors, and buffered by more favorable parent behaviors, in children with severe TBI over the first 12 months post injury. By 18 months post injury, however, the moderating effect of parent behaviors diminished such that children with severe TBI showed more behavior problems relative to children with moderate TBI or OI regardless of parent behaviors or in response to parent behaviors that were initially protective. The results suggest that the moderating effects of the family environment are complex and likely vary in relation to both recovery and developmental factors, with potentially important implications for targets and timing of intervention.

Keywords

pediatric traumatic brain injury; child behavior problems; parenting; recovery; parent-child interactions; moderation

Traumatic brain injury (TBI) is a leading cause of death and disability in childhood. Epidemiological studies suggest that young children (0–4 years of age) are at greater risk for injuries requiring emergency treatment or hospitalization than are older children (Langlois, Rutland-Brown, & Wald, 2006). Children sustaining TBI during early childhood also

experience poorer neuropsychological, psychosocial, and academic outcomes than children injured during later childhood (Anderson, Catroppa, Morse, Haritou, & Rosenfeld, 2005; Anderson et al., 2012; Barnes, Dennis, & Wilkinson, 1999; Ewing-Cobbs & Barnes, 2002; Ewing-Cobbs et al., 1997; Verger et al., 2000), perhaps due to an increased susceptibility to diffuse brain insult and the detrimental effects of brain injury on subsequent development (Ewing-Cobbs et al., 2004; Ewing-Cobbs et al., 1997; Taylor & Alden, 1997). Thus, children sustaining TBI during early childhood are a special population at heightened risk for injury and resulting poor outcomes, underscoring the importance of understanding risk factors and moderating influences on outcomes over time post injury.

Behavioral changes and emerging behavior problems represent the most persistent negative consequence of TBI in children (Rutter, Chadwick, Shaffer, & Brown, 1980) and are associated with impairments in other domains, including adaptive and academic functioning (Arnett et al., 2013; Hawley, 2004; Max, Koele, et al., 1998; Schwartz et al., 2003). A recent review of the literature reported that up to 50% of children sustaining TBI are at risk for behavior problems post injury (Li & Liu, 2013), although estimates reach up to approximately 70% of those sustaining severe injuries (G. C. Fay et al., 1994; Fletcher, Ewing-Cobbs, Miner, Levin, & Eisenberg, 1990; Schwartz et al., 2003). Both “internalizing” and “externalizing” behavior problems are common following pediatric TBI. New-onset depressive disorders occur in 10–25% of school-aged children within two years post injury (Bloom et al., 2001; Max et al., 2012; Max, Koele, et al., 1998) and anxiety disorders and symptoms were reported in 46% of children six months after hospitalization for TBI relative to 14% of those hospitalized for orthopedic injuries (OI; Luis & Mittenberg, 2002).

Attention problems, often diagnosed as “secondary ADHD”, are among the most commonly reported consequences of TBI in children, with 30–50% of children developing symptoms and associated problem behaviors (Konrad, Guggel, Manz, & Scholl, 2000; Max et al., 2004). Risk for other disruptive behaviors is also increased, with approximately 20–40% of children demonstrating oppositional defiant behaviors, including aggression, temper tantrums, and destructiveness (Ganesalingam, Sanson, Anderson, & Yeates, 2007; Max, Castillo, et al., 1998; McKinlay, Grace, Horwood, Fergusson, & MacFarlane, 2010). Although behavior difficulties may resolve within the first year of injury (Bloom et al., 2001), some problem behaviors remain stable or worsen over time, and others may not emerge until several years following the injury (Catroppa, Anderson, Morse, Haritou, & Rosenfeld, 2008; Cattalani, Lombardi, Brianti, & Mazzucchi, 1998; Chapman et al., 2010; T. B. Fay et al., 2009; Schwartz et al., 2003; Taylor et al., 2002). Recent studies have also documented higher rates of mental health difficulties in adult survivors of childhood TBI (Ryan et al., 2013; Ryan et al., 2015; Scott et al., 2014).

Known risk factors for elevated behavior problems following pediatric TBI include greater injury severity (Anderson et al., 2012), younger age (Anderson et al., 2005; Ewing-Cobbs et al., 1997), lower SES (Max et al., 2005a; Schwartz et al., 2003), and premorbid behavior difficulties (Anderson et al., 2012; Max et al., 2005a; Yeates et al., 2005); however, recent research has focused on the influence of the family environment. A variety of family environmental variables are known to influence behavioral outcomes in typically developing children, including family functioning (Brock & Kochanska, 2015; Weeks et al., 2014), parenting style (Luyckx et al., 2011; Rothbaum & Weisz, 1994), and positive and negative

parent-child interactions (Bradley, Conyn, Burchinal, McAdoo, & Coll, 2001; Bradley & Corwyn, 2007; Rubin, Burgess, Dwyer, & Hastings, 2003). In particular, theories of parenting effects on child development, such as those proposed originally by Baumrind and Vygotsky (Baumrind, 1989; Vygotsky, 1978), indicate that certain parenting behaviors are key determinants of age-appropriate behavioral adjustment and self-regulatory skills.

Parent behaviors during parent-child interactions are of particular interest in research because they can be objectively observed and coded in the laboratory (Landry, Smith, Miller-Loncar, & Swank, 1997; Robinson & Eyberg, 1981) and are amenable to change through coaching as the focus of intervention studies (Akai, Guttentag, Baggett, Noria, & Neglect, 2008; Eyberg, Boggs, & Algina, 1995; Guttentag et al., 2014). Research has identified salient dimensions of parent behavior such as warmth, contingent responsiveness (also sometimes called “sensitivity”), negativity (also sometimes called “hostility”), scaffolding, and methods of behavioral control (e.g. directiveness, restrictiveness). Although a comprehensive review is beyond the scope of this paper, low warmth, low contingent responsiveness, high negativity, low frequency of scaffolding, and high frequency of directive and restrictive behaviors in parents of healthy children have all been associated with the development of internalizing and externalizing problems, as well as attention difficulties and slower cognitive and social development (Bates & Pettit, 2015; Denham, Bassett, & Wyatt, 2015; Gauvain & Perez, 2015; Grusec, 2011). Purported mechanisms by which these parent behaviors influence child outcomes include promoting or hindering a child’s capacity to modulate and regulate arousal and emotions (Chang, Olson, Sameroff, & Sexton, 2011; Eisenberg et al., 1999; Tronick, 1989), consider potential consequences of actions (Brody, Dorsey, Forehand, & Armistead, 2002), sustain attention (Landry, Miller-Loncar, Smith, & Swank, 2002), and develop a sense of self (Burge & Hammen, 1991; Downey & Coyne, 1990; Ge, Best, Conger, & Simons, 1996). For example, scaffolding involves the provision of information in the form of conceptual links, as well as other forms of assistance in ways that support children’s developing cognitive and self-regulation skills (Landry et al., 2002; Vygotsky, 1978; Wood, Bruner, & Ross, 1976). Through parental scaffolding or “other regulation,” children gradually learn and internalize skills that allow them to solve problems independently (i.e. self-regulation; Henderson & Moore, 1980; Landry et al., 2002).

Parent behaviors have also been associated with outcomes in children with neurological risk, including children born preterm (Landry et al., 2002), children with very low birth weight (Landry et al., 1997), and children with neonatal/birth complications (M. Wade, Madigan, Akbari, & Jenkins, 2015). Associations of parent behaviors with child outcomes in atypical populations are often stronger than in healthy populations (Landry, Garner, Swank, & Baldwin, 1996; Landry et al., 1997; Landry, Smith, & Swank, 2006), presumably because positive parent behaviors help at-risk children overcome their developmental problems, whereas parent behaviors are less critical for fostering development in healthy children (Landry et al., 1997). Because children with TBI are at increased risk for internalizing, externalizing, and attention problems, and because these problems are associated with parent behaviors in typical and at-risk populations, parent behaviors may play a role in children’s recovery from TBI.

Similar to the effects in typically developing children, greater family dysfunction is associated with more behavioral difficulties following pediatric TBI (Chapman et al., 2010; Crowe, Catroppa, Babl, & Anderson, 2012). In previous reports from the present sample, we have demonstrated that both permissive and authoritarian parenting styles, based on parent self-report questionnaires, increase risk for post injury behavior problems over the first 18 months post injury, whereas authoritative parenting appears to be protective (Chapman et al., 2010; Yeates, Taylor, Walz, Stancin, & Wade, 2010). We also showed that higher observed parental warm responsiveness was associated with lower levels of internalizing and externalizing behavior problems, as well as ADHD symptoms, during the first 6 months post injury, whereas higher observed negativity was associated with higher internalizing problems (S. L. Wade et al., 2011). Similar results have been found in adolescents with TBI, wherein less effective observed parent communication and higher observed parental criticism/coldness were associated with poorer adolescent adjustment (Raj et al., 2014; S. L. Wade et al., 2003). Notably, family environmental factors have predicted child behavior outcomes post injury after accounting for SES and premorbid behavior problems, suggesting that the effects extend beyond differences in access to resources and provide evidence for associations with emergence of new behavior problems following TBI.

Moving beyond the framework of family environmental variables as *independent predictors* of increased behavior difficulties following TBI, recent research demonstrates that family environmental variables may also *moderate* (i.e., buffer or exacerbate) the adverse consequences of pediatric TBI (Yeates et al., 1997). The moderating influence of family environmental factors on neuropsychological, academic, and adaptive functioning has been demonstrated in school-aged children with TBI (Micklewright, King, O'Toole, Henrich, & Floyd, 2012; Taylor et al., 1999; Yeates et al., 1997). In the present sample of children, who sustained their injuries during early childhood, we found that permissive parenting at 18 months post injury moderated the association between injury severity and attention problems at an average of 39 months post injury, such that greater permissiveness was associated with more attention difficulties after severe TBI, but not after moderate TBI or OI (Kurowski et al., 2011). When we directly observed parents and children interacting (S. L. Wade et al., 2011), greater parental warm responsiveness at 6 months post injury moderated the effect of TBI on concurrent externalizing behaviors, such that children with severe TBI and parents high in warm responsiveness had fewer externalizing problems than did those with less responsive parents. Similarly, parental negativity observed both shortly after injury and at 6 months post injury had a moderating effect, such that the presence of negativity was associated with more externalizing and ADHD symptoms at 6 months post injury in the severe TBI group.

Finally, when we followed the present sample out to 18 months post injury (Yeates et al., 2010), higher levels of permissive parenting shortly after injury were associated with more overall behavior problems in children with TBI compared to those with OI, though group differences in behavior problems emerged over time even at lower levels of permissive parenting. In contrast, high levels of authoritarian parenting at baseline were associated with worsening of behavioral adjustment among the TBI groups relative to OI group over time, whereas these differences lessened over time at low levels of authoritarian parenting, especially for the moderate TBI group. These most recent results suggest that the

moderating effects of family environmental factors vary over time since injury. The possibility that the moderating effects of the family environment changes over time is buttressed by evidence that caregiving behaviors change in response to having a child sustain a TBI (Fairbanks et al., 2013; S. L. Wade et al., 2008), both over the course of recovery (Fairbanks et al., 2013) and in response to changes in child behavior post injury (Taylor et al., 2001).

The moderating effects reported by BLINDED et al. (2010), however, were examined in models that examined family factors only at the baseline assessment conducted early after injury. In addition, family factors were limited to parent self-report measures. A more objective characterization of the moderating effects of family environmental factors, and one that would better inform the timing and targets of family intervention, would be provided by direct observation of parent-child interactions and by consideration of time-varying moderation. A significant advantage of time-varying models is that they assess family factors measured both early and later post injury on subsequent child behavior outcomes, taking into account changes in family factors that may occur across follow-up and permitting closer tracking of relations between family status and child behavior. The objective of the present study was to examine the moderating effect of observed parent behaviors over time since injury on the relation between TBI and behavioral outcomes. We hypothesized that young children hospitalized for TBI would display more behavior problems than children with OI, and that these problems would be more prominent in children with more severe TBI. We also hypothesized that observed parent behaviors would moderate the effect of TBI on behavioral outcomes, such that the effect of TBI would be exacerbated in children whose parents demonstrated less favorable parenting behaviors and, conversely, buffered in children whose parents demonstrated more favorable parenting behaviors. Finally, we hypothesized that the moderating effect of observed parent behaviors would vary over time since injury, possibly diminishing in influence over time as children recover from injury.

Method

The study used a prospective, longitudinal, concurrent cohort research design to examine behavioral outcomes in young children with TBI and young children with OI and their families. Children and their families were assessed shortly after injury and again at 6 months, 12 months, and 18 months post injury. The use of an OI comparison group increases the likelihood that the groups are comparable in terms of pre-injury behavioral adjustment and family functioning, factors that have been shown to contribute to the risk for injury (both TBI and OI), may relate to pre-injury parent-child interactions (Goldstrohm & Arffa, 2005), and are likely to be associated with post injury behavior difficulties (Max et al., 2005a, 2005b). The study was approved by the Institutional Review Boards at each of the participating medical centers, and informed consent was obtained from participating caregivers.

Recruitment Criteria

Consecutive admissions of children with TBI or with OI not involving the central nervous system (CNS) were screened at three tertiary care children's hospitals and a general hospital

(all with Level 1 trauma centers) in BLINDED. Eligibility requirements for both groups included age between 36 to 84 months at the time of injury and English as the primary spoken language in the home. Eligibility for the TBI group also included a TBI requiring overnight admission to the hospital with a Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) score of 12 or less or a higher score accompanied by abnormal neuroimaging (magnetic resonance imaging [MRI] or computed tomography [CT] scan) as defined by an intracranial or parenchymal injury or depressed skull fracture. Children with non-blunt head trauma (e.g., projectile wounds, strokes, drowning) were excluded. Consistent with previous investigations (Anderson et al., 2006; Fletcher et al., 1990; Taylor et al., 1999), a GCS score of 8 or less defined a severe TBI. Complicated mild to moderate TBI (henceforth referred to as 'moderate TBI') was defined as a GCS score of 9–12 with or without abnormal neuroimaging (moderate TBI) or a higher GCS score with abnormal neuroimaging (complicated mild TBI). The GCS score assigned to the child was the lowest one recorded post resuscitation. Because the focus of this study was on children with complicated mild to severe TBI, a small group of children with uncomplicated mild TBI was excluded from analysis. Inclusion in the OI group required a documented bone fracture (other than the skull), an overnight hospital stay, and the absence of any evidence of loss of consciousness or other findings suggestive of brain injury (e.g., symptoms of concussion). Parents of all children meeting these criteria were contacted either during the child's hospital stay or subsequently by letter and follow-up phone calls to conduct further screening and recruit the family for participation. As part of the recruitment screening procedure, children were excluded if they had any of the following: previous history of brain injury; preexisting neurological disorder or medical problem affecting the CNS; diagnosis of mental retardation, autism, or neurological disorder; documentation in the medical chart or in the parent interview of child abuse as the cause of injury; or history of severe psychiatric disorder requiring hospitalization.

Sample Characteristics

A total of 206 children and their caregivers (87 with TBI and 119 with OI) completed informed consent and were originally enrolled in the study. Baseline data were collected on 204 children and caregivers (87 with TBI and 117 with OI). The sample included 54% of eligible children with TBI and 35% of eligible children with OI. Comparison of enrolled children with those in the Trauma Registry at participating hospitals meeting age and injury severity criteria indicated that our sample was representative of all eligible children in terms of race and family income (based on median income from the 2005 Census for the child's address). All but six children (97%) completed the videotaped interaction tasks at the baseline assessment, and an additional four children had unusable videotapes and were thus excluded from the analyses (see S. L. Wade et al., 2008 for a more complete description of the baseline sample). The primary caregiver was the child's mother in all but eight families (96%). In these families, fathers (three), grandmothers (four), or permanent legal guardians (one) served as the primary caregiver and completed the parent-child interaction task. Socioeconomic status (SES) was defined by averaging sample *z* scores for maternal education and median income for the family's census tract, referred to as the SES *z* score (Yeates et al., 2010).

The sample included in the present study comprised the 167 children with data for all relevant predictors who had completed at least one of the 6-, 12-, or 18-month post injury assessments (20 with severe TBI, 52 with moderate TBI, and 95 with OI). Although participants did not differ significantly from non-participants in sex, race, or age at injury, participants had significantly higher SES z scores, $t(197) = 2.64$, $p = .009$, likely reflecting greater difficulties tracking the less advantaged families. Group comparisons revealed that children with severe TBI were hospitalized longer than children in the other two groups (Table 1). The time between injury and baseline assessment was longer for the TBI group ($M = 46.5$ days, $SD = 24.3$) than for the OI group ($M = 34.6$ days, $SD = 15.1$; $t(111.48) = 3.64$, $p < .001$) because of difficulties recruiting and testing children acutely following TBI. As reported previously (S. L. Wade et al., 2008), the groups did not differ with respect to pre-injury delays in growth, development, learning difficulties, or problems with emotions and behavior, suggesting that the children had comparable rates of developmental and behavioral concerns prior to the injury. Group comparisons also failed to reveal differences in racial composition, but a higher proportion of mothers of children in the OI group completed at least a high school education relative to mothers of children in the severe TBI group, and a similar trend was found for family income.

Procedures

Observations of parent behaviors during videotaped parent-child interactions were conducted shortly after the injury at the baseline assessment and again at 6 and 12 months post injury. Parent ratings of *pre-injury* child behavior problems were collected at the baseline evaluation. Parent ratings of post injury behavior problems were collected at 6, 12, and 18 months post injury.

Measures

Ratings of parent and child behaviors during parent-child interactions—To rate parent behaviors, we employed the coding system used by Landry and colleagues (Landry et al., 1997) in their studies of outcomes in low-birth-weight children. This system incorporates ratings of parent behaviors that reflect more enduring dispositions or interactive styles (Bakeman & Brown, 1980). Parent behaviors are measured using both molar (rating scale) and micro (frequencies of behaviors) methods to reflect a broad range of parental characteristics. Considerable support exists regarding the predictive validity of these ratings for subsequent child cognitive and social development (Landry et al., 2002; Landry et al., 1997; Landry, Smith, Swank, Assel, & Vellet, 2001).

Parent-child dyads were videotaped during 10-minutes of a structured task and 10-minutes of free play, each of which was divided into two 5-minute segments for rating purposes and transcribed to facilitate coding of parent verbalizations. During the structured task, the parents and children were required to complete a series of puzzles together that were selected based on the likelihood of the child needing some parental assistance to complete. During the free play interactions, parents and children were instructed to spend time together as they normally would at home. Children in the free play situation were able to engage in enjoyable activities with opportunities for interaction with their parent in the absence of any stated expectations for performance. The room was equipped with developmentally

appropriate toys, a TV, and magazines for the parent to read. The free play situation was designed to elicit parent–child interactions similar to those that might be observed in the child’s home or other everyday situation, thereby increasing ecological validity.

Parent behavior was coded along the dimensions of *warmth*, *contingent responsiveness*, and *negativity*. Raters provided a global rating of each dimension along a 5-point scale for each 5-minute segment, with higher scores indicating more positive behavior (i.e., high warmth, minimal negativity). Parental warmth was rated on the basis of the presence and intensity of verbal and nonverbal warmth, affection, and positive regard toward the child. Contingent responsiveness ratings reflected the degree of the parent’s sensitivity and responsiveness to the child’s behavior (see S. L. Wade et al., 2008 for a more complete description). Negativity was rated on the basis of the presence of a harsh or angry tone of voice, sarcasm and demeaning comments, physical control such as slaps or pinches, and physical expressions of impatience (eye-rolling, sighing).

Parent behavior was also coded for the frequency of *scaffolds*, *directives*, and *restrictive behaviors*. The frequency of each behavior was divided by the total of the three types of behaviors to calculate a proportional value for each type in order to control for differences between parents in the amount that they engaged the child. Scaffolds (considered a positive or facilitative parent behavior) were coded when parents provided conceptual links between objects, persons, activities, or functions (e.g. “That’s a giraffe. You saw one at the zoo.”). Directives (considered as less positive or facilitative, especially during play) include parental strategies to focus the child’s attention while providing more information about what to do and/or fewer choices (e.g. “Put the dog in the barn”). Restrictive behaviors are verbal or nonverbal behaviors that limit, restrict, or discipline the child’s behavior in some way (e.g. “Calm down” or shaking head to indicate “no”). Because scaffolds and directives during free play were highly inversely correlated ($r = -.78$), analysis of parent behavior during free play considered only scaffolds and restrictive behaviors.

Although child behaviors during the parent–child interactions were not the focus of the present study, child behaviors were also coded using the coding system used by Landry and colleagues (Landry et al., 1997). Although this coding system does not provide information on dyadic interactions between individual child and parent, associations of child and parent behaviors provide a context for interpreting the parent behaviors. During the free play condition, coders rated the child’s *warmth* toward the parent on the basis of the amount of talking, eye contact, smiling/positive affect, and verbal and nonverbal efforts to engage the parent. During the structured task condition, coders rated the child’s *cooperation* and *behavioral dysregulation*. Child cooperation was rated on the basis of the child’s listening to parent’s suggestions, tolerance of denial of wishes or requests and toleration of making choices, receptivity to redirection, and expanding on parent’s requests rather than giving minimal responses. Child behavioral dysregulation was rated on the basis of the presence of hypersensitivity to challenges or parental requests, inability to adjust to changes, extremes in affect, expression of wants and needs in inappropriate ways, and difficulty with self-regulation (e.g. tantrums, screaming). Child behaviors were also rated along a 5-point scale, with higher scores indicating more positive behavior (i.e., high warmth, minimal behavioral dysregulation).

Each 5-min segment was coded independently, with ratings for the two free play segments and two structured task segments averaged to increase the stability of these measures. To assess inter-rater reliability, 15% of the tapes were rated by the entire rating team. Each rater's reliability with the group ratings was assessed using intraclass correlation coefficients (ICC). ICCs for all codes and raters were .8 or greater (range = .80–.99) indicating a high level of inter-rater reliability. Although raters were not informed of the group status of parent–child dyads, some children in both groups had casts indicative of orthopedic injuries, and some children with severe TBI had visible speech or motor impairments associated with their injuries at the baseline assessments. Therefore, complete concealment of injury status from the raters was not always feasible.

Correlations among parent behaviors across time points by condition are provided in Table 2. Scales with correlations exceeding .75 were averaged to form composites. Based on this criterion, parental warmth and contingent responsiveness were averaged into a single scale of “warm responsiveness” reflecting positive parenting behavior (see also Landry et al., 2006). Parental negativity was not highly correlated with positive parenting behaviors ($r = -.20$ to $-.34$) and was thus retained as a separate scale. Ratings of negativity were highly skewed, however, with less than 10% of parents receiving ratings of less than 4 (slightly negative). As a result, a dichotomous measure of negativity (present vs. absent) was used as the predictor in the analyses. Changes in parent behaviors over time were previously reported in BLINDED and colleagues (Fairbanks et al., 2013). Compared to parents in the OI group, those in the moderate TBI group demonstrated lower levels of warm responsiveness at baseline during free play and at both baseline and 6 months post injury during structured activities. These differences, however, were no longer significant by 12 months post injury. No significant differences emerged between the severe TBI and OI group at any time point.

Correlations of child behaviors with parent behaviors by time point and condition are provided in Table 3. Across visits, parents of children who were higher in warmth were themselves also higher in warmth, contingent responsiveness, and scaffolds, and lower in directiveness. Parents of children who were higher in cooperation were higher in scaffolding and lower in negativity and restrictiveness. Parents of children who had better behavioral regulation were higher in warmth, contingent responsiveness, and scaffolding, and lower in negativity and restrictiveness, although associations were weaker at 12 months post injury.

Parent ratings of child behavior problems—Parents completed the age-appropriate form of the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) at baseline and all three follow-up assessments. The CBCL is a commonly used parent-report measure of child behavior problems and possesses high test–retest reliability and criterion-related validity. At baseline, parents were asked to complete the CBCL based on the child's pre-injury behaviors. Although the time between injury and baseline assessment was longer for the TBI group than for the OI group, we found no significant group by time since injury interactions on baseline reports of pre-injury child behavior (all $p > .05$). In addition, no significant differences were found among the groups in pre-injury child behavior problems, although children in the severe TBI group consistently showed trends for more pre injury behavior problems. The effect of time since injury was significant for ADHD symptoms

only, with greater time since injury associated with fewer symptoms of ADHD, indicating a possible “good old days” bias (Brooks et al., 2014) on pre-injury behaviors that held across groups. To assess the potential consequences of TBI on behavior, we focused on the T-scores for Internalizing and Externalizing problems and the raw score on the Attention-Deficit/Hyperactivity (ADHD) scale (Bloom et al., 2001; Max et al., 2005a, 2005b). The ADHD Scale contains items assessing common symptoms of ADHD, including difficulties with concentration, sitting still, impulsiveness, and inattention. Raw scores were used for this scale due to the restricted range of T-scores (Chapman et al., 2010). Correlations among the scales considered in this study ranged from .57 (between Internalizing and ADHD) to .80 (between Externalizing and ADHD) at all time points. Table 4 reports the proportion of children in each group exceeding borderline clinical cutoffs on the CBCL at each time point as defined by T-scores >63, or <10th percentile relative to the normative sample, corresponding to cutoffs used to identify clinical “caseness” by Schwartz et al. (2003).

Additional measures of the family environment—Caregiver psychological distress at baseline was measured using the Brief Symptom Inventory (BSI; Derogatis & Spencer, 1982), a 53-item questionnaire tapping a wide range of psychological symptoms. Reliability and validity are well established. Overall parent psychological distress on this measure was summarized using the Global Severity Index (BSI-GSI). The 12-item General Functioning Scale (GF) of the Family Assessment Device (FAD; Miller, Bishop, Epsten, & Keitner, 1985) was administered to assess global preinjury family functioning at baseline. The FAD-GF has demonstrated reliability and validity and correlates highly with other FAD subscales. Higher scores on the FAD-GF indicate greater family dysfunction. These measures were included to allow us to statistically control for the effects of caregiver distress and family functioning when examining the relation between parenting behaviors and child behavior problems.

Statistical Analysis

We employed linear mixed models using a lagged, time-varying moderator analysis to examine the relationship of observed parent behaviors during both the structured task and free play, conditions at the baseline, 6-month, and 12-month assessments to child behavior problems at 6 months, 12 months, and 18 months post injury, after controlling for pre-injury levels of child behavior problems. Lagged models were applied on the assumption that parent behavior at the beginning of the interval over which change in child behavior problems was assessed would provide the most proximal assessment of parent influences operating during that interval. Children with TBI were divided into moderate and severe groups on the basis of the severity of injury, with the OI group serving as a reference category. Dummy coding was used to contrast the moderate and severe TBI groups with the OI reference group. Covariates included the SES *z* score, the CBCL form version (preschool vs school-age), age at injury, and the BSI-GSI. Other factors, including the FAD-GF, race, and gender were excluded after preliminary analysis failed to reveal significant associations of these variables with child behavior.

Moderating effects of parent behaviors on group differences and on group differences across time were examined by including parent behavior x group and parent behavior x group x

time interactions in the models. Parent behavior was included in the models as a lagged time-varying factor. When a significant moderating effect was detected, post hoc analyses examined injury group differences at high and low levels of parent behavior, and when a significant time-varying moderating effect was detected, post hoc analyses examined injury group differences at high and low levels of parent behavior at each time point.

Participants were considered random effects with a corresponding random slope with respect to time since injury. After fitting an initial model, we tested the significance of random and fixed effects and reduced model complexity to achieve the most parsimonious model. The random slope with respect to time since injury was trimmed from the models predicting ADHD symptoms due to non-significance. We followed an iterative process, eliminating predictors for which the *F* tests for fixed effects were not significant, starting with three-way interactions, and then re-estimating the model before examining lower-level interactions and, finally, main effects. For any significant interaction, all of the main effects and lower-level interactions upon which the significant interaction was based were retained in the model.

An alpha of .05 was used despite multiple comparisons to reduce the risks of Type II error associated with tests of interactions in non-experimental designs (McClelland & Judd, 1993) and because interactions were the primary focus of the study. However, effect sizes were computed by standardizing all continuous predictors ($M = 0$, $SD = 1$) other than time since injury and obtaining parameter estimates based on the final mixed model for each dependent variable. The resulting coefficients are akin to standardized regression coefficients for continuous predictors and to standardized mean differences (e.g., d) for categorical variables. Because standardized regression coefficients can be scaled to correlations (Cohen, 1988), we used conventional definitions of effect size for correlations to characterize the magnitude of the standardized parameter estimates for continuous predictors and interactions involving only them (i.e., 0.1 is small, 0.3 is medium, and 0.5 is large). Likewise, we used conventional definitions of effect size for mean differences to characterize the magnitude of parameter estimates for categorical predictors and any interactions involving them (i.e., 0.2 is small, 0.5 is medium, 0.8 is large). In addition, because of the relatively small sample size of the TBI groups, we also employed influence diagnostics to examine whether significant results were driven by outliers (Cook & Weisberg, 1982). Using Cook's Distance of >1 as a criterion, no models were driven by "influential observations" (e.g. outliers). Analyses were conducted using SAS Version 9.3.

Results

Moderation Effects of Observed Parent Behaviors

Warm responsiveness during structured task and ADHD symptoms—Under the structured task condition, a significant warm responsiveness $\times$ group $\times$ time since injury interaction was found for symptoms of ADHD (see Table 3), indicating that warm responsiveness moderated the effect of TBI on symptoms of ADHD and that the moderating effect varied over time since injury. Warm responsiveness significantly moderated the severe TBI vs. OI group contrast with a medium effect size, $t(251) = 2.50$, $p = .013$, standardized estimate = 0.49, but did not significantly moderate the moderate TBI vs. OI group contrast, $t(251) = 0.15$, $p = .879$, standardized estimate = 0.02. The moderating effect of warm

responsiveness is plotted in Figure 1, which presents model estimates of ADHD symptoms at low and high levels of warm responsiveness, corresponding to sample values falling at the 10th and 90th percentiles, respectively. Post hoc contrasts revealed that lower warm responsiveness at baseline was associated with significantly more ADHD symptoms at 6 months post injury in the severe TBI group relative to both the moderate TBI group, $t(251) = 4.05$, $p < .001$, standardized estimate = 1.07, and the OI group, $t(251) = 4.35$, $p < .001$, standardized estimate = 1.16. In contrast, the three groups of children with highly warm responsive parents at baseline were comparable in ADHD symptoms at 6 months post injury. Lower warm responsiveness during the structured task at 6 months post injury continued to be associated with significantly more ADHD symptoms at 12 months post injury in the severe TBI group relative to both the moderate TBI group, $t(251) = 4.34$, $p < .001$, standardized estimate = 0.83, and the OI group, $t(251) = 4.84$, $p < .001$, standardized estimate = 0.92. Higher warm responsiveness during the structured task at 6 months post injury was associated with significantly more ADHD symptoms in the severe TBI group relative to the OI group, $t(251) = 2.16$, $p = .031$, standardized estimate = 0.20, but not the moderate TBI group. By 18 months post injury, the moderating effect of parental warm responsiveness had diminished, such that the severe TBI group demonstrated significantly more ADHD symptoms relative to both the moderate TBI group and the OI group, regardless of whether they were exposed to high or low levels of warm responsiveness at 12 months post injury: for severe TBI vs. moderate TBI, low warm responsiveness: $t(251) = 2.88$, $p = .004$, standardized estimate = 0.59; high warm responsiveness: $t(251) = 2.59$, $p = .010$, standardized estimate = 0.69; for severe TBI vs. OI, low warm responsiveness: $t(251) = 3.41$, $p < .001$, standardized estimate = 0.69; high warm responsiveness: $t(251) = 3.29$, $p = .001$, standardized estimate = 0.80.

Warm responsiveness during free play and ADHD symptoms—Under the free play condition, a significant warm responsiveness x group interaction was found for symptoms of ADHD (see Table 3); the three-way interaction involving time since injury was not significant and was, therefore, trimmed from the model. Warm responsiveness significantly moderated the severe TBI vs. OI contrast, with a small effect size, $t(253) = -2.33$, $p = .021$, standardized estimate = -0.23, but not the moderate TBI vs. OI contrast, $t(253) = -1.42$, $p = .157$, standardized estimate = -0.10. Figure 2 illustrates the interaction by plotting model estimates for ADHD symptoms at low and high levels of responsiveness, as defined earlier. Post hoc contrasts revealed that lower warm responsiveness during free play across time since injury was associated with significantly more ADHD symptoms in the severe TBI group relative to both the moderate TBI group, $t(253) = 4.19$, $p < .001$, standardized estimate = 0.73, and the OI group, $t(253) = 5.32$, $p < .001$, standardized estimate = 0.91. In contrast, higher responsiveness was associated with smaller group differences in ADHD symptoms, although the severe TBI group continued to have significantly more ADHD symptoms than the moderate TBI group, $t(253) = 2.00$, $p = .046$, standardized estimate = 0.44.

Scaffolds during free play and internalizing problems—Under the free play condition, a significant scaffolds x group x time since injury interaction was found for internalizing problems (see Table 3), indicating that the proportion of scaffolds during free

play moderated the effect of TBI on internalizing problems and that the moderating effect varied over time since injury. Scaffolds significantly moderated the severe TBI vs. OI group contrast, with a medium effect size, $t(248) = 2.02$, $p = .045$, standardized estimate = 0.51, and also significantly moderated the TBI vs. OI group contrast, but with a small effect size, $t(248) = -2.24$, $p = .026$, standardized estimate = -0.30. To illustrate this interaction, Figure 3 plots model estimates for internalizing symptoms at low and high levels of scaffolding, as defined earlier. Post hoc contrasts revealed that a lower proportion of scaffolds during free play at baseline was associated with significantly higher internalizing problems at 6 months post injury in the severe TBI group relative to the moderate TBI group, $t(248) = 2.42$, $p = .016$, standardized estimate = 0.72, and marginally higher internalizing problems relative to the OI group, $t(248) = 1.83$, $p = .068$, standardized estimate = 0.52. Similarly, a higher proportion of scaffolds during free play at baseline was associated with marginally lower internalizing problems at 6 months post injury in the severe TBI group relative to the moderate TBI group, $t(248) = -1.95$, $p = .053$, standardized estimate = -0.85, but, contrary to expectations, significantly higher internalizing problems in the moderate TBI group relative to the OI group, $t(248) = 2.53$, $p = .012$, standardized estimate = 0.51. A lower proportion of scaffolds during free play at 6 months post injury continued to be associated with marginally higher internalizing problems at 12 months post injury in the severe TBI group relative to the moderate TBI group, $t(248) = 1.69$, $p = .093$, standardized estimate = 0.33, and significantly higher internalizing problems relative to the OI group, $t(248) = 1.98$, $p = .048$, standardized estimate = 0.37. In children exposed to a high proportion of scaffolds during free play at 6 months post injury, the severe TBI group was no longer significantly different in internalizing problems from the OI group at 12 months post injury but the moderate TBI group continued to demonstrate higher internalizing problems relative to the OI group, $t(248) = 2.27$, $p = .024$, standardized estimate = 0.33. At 18 months post injury, the protective moderating effect of a high proportion of scaffolds during free play was opposite to expectations, such that children in the severe TBI group exposed to a high proportion of scaffolds at 12 months post injury demonstrated higher internalizing problems relative to both the moderate TBI group, $t(248) = 2.36$, $p = .019$, standardized estimate = 0.59, and the OI group, $t(248) = 3.19$, $p = .002$, standardized estimate = 0.74. In contrast, children in all three groups exposed to a low proportion of scaffolds at 12 months post injury were comparable in internalizing problems at 18 months post injury.

Main Effects of Group, Parenting Behaviors, and Time Since Injury

Analysis revealed several main effects involving factors that were not included in higher-order interactions. The effect of group was significant across models. The severe TBI group showed higher internalizing (standardized estimate = 0.38), externalizing, (standardized estimate = 0.45), and ADHD symptoms (standardized estimate = 0.67) relative to the OI group. The moderate TBI group was comparable to the OI group in behavior problems.

Warm responsiveness during the structured task or free play had no significant main effect on child internalizing or externalizing behaviors. Negativity also had no effect within either condition. A higher proportion of scaffolds during free play (standardized estimate = -0.07) and during the structured task (standardized estimate = -0.09) was significantly associated with fewer externalizing problems across groups. There was no significant effect of scaffolds

during the structured task or free play on symptoms of ADHD or of scaffolds during the structured task on internalizing problems. There were no significant main effects of restrictive behaviors.

Time since injury had a significant main effect across groups on internalizing symptoms (standardized estimate = -0.14) and externalizing symptoms (standardized estimate = -0.14), such that behavior problems decreased slightly across groups over time. There was no significant main effect of time since injury on symptoms of ADHD.

For each of the models with significant interactions or main effects, higher pre-injury behavior problems (standardized estimate = 0.68) and higher parent psychological distress at baseline (standardized estimate = 0.20) were significantly associated with higher post injury behavior problems. In addition, younger age at injury was significantly associated with higher externalizing problems across groups (standardized estimate = -0.11), but was not significantly associated with internalizing problems or symptoms of ADHD. Finally, parent ratings of externalizing problems were higher on the school-age version of the CBCL than on the preschool version (standardized estimate = -0.49).

Discussion

The present study sought to examine the moderating effect of observed parent behaviors over time since injury on the relation between TBI and behavioral outcomes. As hypothesized, the effect of TBI on behavior was exacerbated by less favorable parent behaviors, and buffered by more favorable parent behaviors, in children with severe TBI over the first 12 months post injury. By 18 months post injury, however, the moderating effect of parent behaviors largely diminished such that children with severe TBI showed more behavior problems relative to the moderate TBI and OI groups regardless of parent behaviors or in response to parent behaviors that were initially protective. The results suggest that not only do parent behaviors moderate recovery following TBI sustained during early childhood, but that the moderating effects of the family environment are complex and likely vary in relation to both recovery and developmental factors, with potentially important implications for targets and timing of interventions.

Diminishing Effects of Warm Responsiveness over Time Since Injury

Children with severe TBI exposed to low warm responsiveness during the structured task at baseline and 6 months post injury showed higher ADHD symptoms relative to both the moderate TBI and OI groups at 6 and 12 months post injury. These differences at 6 and 12 months were not evident in the context of high warm responsiveness, although the severe TBI group showed higher ADHD symptoms relative to the other two groups at 18 months post injury regardless of the level of warm responsiveness. A similar moderating effect on ADHD symptoms, albeit one that did not vary with time since injury, was found for warm responsiveness during free play. The lack of time-varying findings for the moderating effect of warm responsiveness during the free play condition might suggest that parent behaviors during play have a longer-lasting effect on recovery from TBI as compared to parent behaviors during more task-oriented conditions. This could be because parent behaviors during play may be more reflective of parenting in the home setting than parent behavior

during a more structured task. Alternatively, the moderating effect of warm responsiveness during play may diminish over time, though to a lesser degree that was not detected due to the small sample sizes of the TBI groups and difficulty in detecting interaction effects.

The results from the structured task condition suggest that higher parental warm responsiveness is protective for children with TBI until approximately one year post TBI, after which it may no longer exert this protective effect. The role of warm responsiveness in reducing emerging behavior problems following TBI sustained in early childhood is consistent with considerable previous literature documenting the relationship of positive parenting qualities, such as warmth, approval, responsiveness, and synchrony, with more favorable child adjustment and fewer externalizing problems in typically developing children (Bradley & Corwyn, 2007; Davidov & Grusec, 2006; Rothbaum & Weisz, 1994). Children's behavior is frequently dysregulated during the sub-acute phase of recovery from TBI. Parental warm responsiveness may provide consistent, positive feedback from the environment that, in turn, facilitates self-regulation during the early stages of recovery.

The pattern of diminishing moderating effects of warm responsiveness during the structured task on ADHD symptoms by 18 months post injury is consistent with our previous report of diminishing moderating effects of parent's self-reported parenting styles on children's general behavioral adjustment (CBCL Total Problems Score) over the same period of time post injury in the same sample (Yeates et al., 2010). However, this previous study included only the baseline measure of parent behaviors in their statistical models; whereas the present analyses allowed the moderator to vary over time. The moderators in our models were measured only 6 months prior to the assessment of the outcomes, making it less likely that moderating effects diminished over time due to remoteness of moderator measurement.

The reason for the diminishing effects of parent behaviors over time following pediatric TBI is yet to be determined. One possibility is that parent behaviors have the most influence on child behaviors during the first year post injury when the majority of neural recovery is taking place, but that after this period, behavior problems become more intransigent. Another potential explanation is that parent behaviors such as warm responsiveness and scaffolding have the most influence during the preschool years, perhaps because the child spends more time with parents during this time or because of a critical period of development that is most sensitive to the influence of parent behaviors (Landry, Smith, Swank, & Guttentag, 2008). Other family environmental factors, such as overall parenting style, may be more important for moderating outcomes as the child enters middle childhood (Kurowski et al., 2011). Although child behavior problems slightly decreased over time in the sample as a whole, behavior problems in children with severe TBI increased over time, regardless of parental warm responsiveness. This increase in behavior problems at 18 months post injury may signal the beginning of a trend of ongoing increases in behavior problems over time since injury as demands for behavioral control increase throughout childhood, as has been observed in other samples (Anderson et al., 2006; Catroppa et al., 2008; T. B. Fay et al., 2009). A related possibility is that parent behaviors that were initially effective in mitigating behavior problems when children were younger are less apt to moderate behavior problems as children enter challenging transitional periods of development. Because we only report on child outcomes up to 18 months post injury, future

studies are needed that examine the moderating influence of the family environment during longer-term follow-up of children sustaining early TBI as they face the increasing demands of middle school and early adulthood.

Changes in Moderating Effects of Scaffolds/Directives over Time Since Injury

Parental scaffolding during free play moderated the effect of TBI on internalizing problems, such that initially, a lower proportion of scaffolds during free play at baseline was associated with higher internalizing problems, and a higher proportion of scaffolds was associated with lower internalizing problems, at 6 months post injury in the severe TBI group relative to the moderate TBI and OI groups. At 12 months post injury, the moderating effect of parental scaffolds had somewhat diminished, with smaller differences between groups. By 18 months post injury, the moderating effect of a high proportion of scaffolds was opposite to expectations, such that children in the severe TBI group exposed to a high proportion of scaffolds at 12 months demonstrated *higher* internalizing problems relative to both the moderate TBI and OI groups. In contrast, children exposed to a low proportion of scaffolds at 12 months post injury were comparable in internalizing problems at 18 months post injury. We should note that similar findings were found for directives during free play (i.e., a lower proportion of directives was at first protective for internalizing symptoms in the severe TBI group, but by 18 months post injury, a lower proportion of directives was associated with higher internalizing problems in that group); however these results were not reported to avoid redundancy because of the substantial inverse correlation between directives and scaffolds during free play.

The change in the moderating effect of scaffolds and directives on child internalizing problems is challenging to interpret. Parent behaviors that are effective in managing younger children may be less effective, and perhaps even irksome, for older children. For example, with increasing age, children may become less accepting or tolerant of parent efforts to manage their behaviors using techniques such as scaffolding. Changes in parent behaviors over the child's recovery trajectory may also help account for changes over time in the moderating effects of scaffolds and directives. A high number of scaffolds could be facilitative for a child with severe TBI and resultant neuropsychological impairments during the sub-acute phase of recovery. As the child recovers, however, parents may need to fade behaviors such as scaffolding over time. The association between high scaffolding and high internalizing problems further out from injury may reflect a mismatch between the child no longer needing a high number of scaffolds and a parent's continued provision of them. Finally, changes with increasing time post injury may reflect bidirectional influences on child and parent behaviors following TBI. As suggested by Taylor et al. (2001), emerging child behavior problems following TBI may adversely influence parent behaviors, which, in turn, may contribute to greater child dysfunction. Parents of children with severe TBI who develop internalizing problems may attempt to compensate for the child's emotional sensitivity by providing a high proportion of scaffolds (and associated low level of directives). Thus, parents may change their behaviors in response to the emergence of internalizing behavior problems among children with severe TBI, potentially explaining the change in the moderating effect of high scaffolds. The significant associations among child and parent behaviors presented in Table 3 support this notion of reciprocity. Although each

of these interpretations are speculative and require further investigation, the results clearly suggest that the optimal parent behaviors change over time since injury, likely in response to developmental and recovery factors. Thus, parent behaviors that might be facilitative for child behavior during the sub-acute phase of recovery might become detrimental during later phases of recovery.

Notably, the moderating effect of parent behaviors was significant only for children with severe TBI. This pattern of findings is consistent with previous studies of the moderating influence of the family environment following TBI sustained during both early (Kurowski et al., 2011; S. L. Wade et al., 2011; Yeates et al., 2010) and later childhood (Taylor et al., 2002; Yeates et al., 2002). Studies of other populations of at-risk children have also documented the strongest moderating influences of the family environment in children at the greatest neurological risk (Landry, Chapieski, Richardson, Palmer, & Hall, 1990; Landry et al., 1997; M. Wade et al., 2015). A possible basis of these observations is that positive parent behaviors are most effective in children with the types of dysregulated behaviors that characterize severe TBI, whereas parent behaviors are less critical for fostering development in healthy children or children less affected by brain injury. Along the same lines, the relative infrequency of emerging behavior problems following moderate TBI and OI may leave little variance to be explained by family factors (T. B. Fay et al., 2009). Finally, the mechanisms underlying moderation of the family environment on behavior problems following TBI presumably involve alteration of neural substrate and its recovery processes. With less severe TBI, there may be less opportunity for these mechanisms to exert their effect. Investigation into the neural mechanisms underlying the moderating effects of environmental factors on recovery following early childhood TBI would be illuminating.

Clinical Implications

The results suggest that the first year post injury may be the optimal time to ameliorate or prevent deterioration in behavior following early TBI by training parents in positive parenting skills, such as warmth, contingent responsiveness, and scaffolding (Antonini et al., 2014). The findings, however, also suggest that after one year post injury, improving parenting may have less of an effect on emerging behavior problems, especially for children with severe TBI. The results highlight the first year post injury as a time during which problem behaviors emerge or worsen and become less responsive to parent behaviors. As such, intervention research should investigate time since injury as a key moderator of intervention effectiveness and consider alternate approaches to positive parenting skills for intervention during the long-term phase of recovery.

Limitations

The current findings must be considered in the context of certain limitations. Child behaviors were assessed by parent report, and are confounded to some extent with parent behaviors and perceptions, potentially inflating the association between parenting behaviors and child behavior problems. Indeed, we found that parental distress was related to their ratings of child behavior problems, although moderating effects were found in models that controlled for this factor. Future research might examine teacher reports of child behavior to address this limitation. In addition, the interval between injury and retrospective parent

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ratings of child behavior varied across groups. Baseline parent ratings of pre-injury ADHD symptoms were negatively correlated with increasing time since injury, suggesting a “good old days” bias, which may also have inflated post-injury changes in ADHD symptoms. This association, however, was consistent across groups, so that it is unlikely to have influenced group interactions. A related issue is that early post injury changes in child behavior due to TBI may have led to changes in parenting and thus contributed to the associations between initial parenting behavior and 6 month post injury child behavior problems. Although this possibility does not account for the subsequent lagged associations between parenting and child behavior problems, future research should measure more immediate child behavioral change. Dyadic coding of parent-child interactions would also have provided more information on the extent to which child behavior was an antecedent or consequent of parent behavior.

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It was surprising that neither parental negativity nor restrictive behaviors were significantly associated with child behavior problems. This finding is in contrast to our previous report (S. L. Wade et al., 2011), in which higher parental negativity, both at baseline and 6 months post injury, was significantly associated with higher levels of externalizing behaviors at 6 months post injury following severe TBI; restrictive behaviors were not previously examined in this sample. The difference in findings are likely attributable to the slightly smaller sample size (due to attrition over time) of the present report resulting in less statistical power, as well as the different statistical approaches used. In addition, because parental displays of negativity were so infrequent, the previous findings were likely attributable to only a few parent-child dyads and may not have been reliable. Moreover, parents’ awareness of being observed may have caused changes in their behavior. Because ratings of parental behavior were made based on relatively brief structured interactions in the laboratory, they may not fully capture the range of the parent’s behavior in the home setting. In particular, parents may have been less likely to engage in negative or harsh behaviors toward the child, resulting in a restricted range of negativity. Longer observations in more naturalistic environments (i.e., home) may serve to address these concerns. Administration of more detailed measures of child behavior problems, such as structured clinical interviews, may also be useful in further studies of the relation of parenting characteristics to child behavior problems after TBI.

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Finally, the relatively small sample sizes of the TBI groups, especially the severe TBI group, are a significant limitation of the present study. The small sample sizes may have reduced statistical power to detect interactions, in addition to raising concern regarding the possibility of outliers driving results. Although the model diagnostics indicated that outliers did not account for the significant findings within the severe TBI group, confidence in the present findings will be bolstered by replication in larger samples of children with moderate to severe TBI.

Conclusions

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Parenting behaviors are an important moderator of the effect of TBI on emerging child behavior problems. The present results confirm and extend previous findings suggesting that the moderating effect of family environmental factors varies as a function of multiple factors, including injury severity, time since injury, the specific dimension of parent behavior

under consideration, and the type of problem behavior assessed (Taylor & Alden, 1997), as well as recovery and developmental factors. The presence of multiple indications of similar moderating effects argues strongly for the existence of a complex interplay between the damaged brain, its environmental context, and post injury changes in behavioral outcomes following TBI in young children.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Warm responsiveness during structured task and ADHD symptoms. ADHD symptoms over time since injury as a function of Group Membership and Parental Warm Responsiveness during the Structured Task Condition (low vs. high)

Figure 2.

Warm responsiveness during free play and ADHD symptoms. ADHD symptoms averaged across time since injury as a function of Group Membership and Parental Warm Responsiveness during the Free Play Condition (low vs. high)

Figure 3. Scaffolds during free play and internalizing problems. Internalizing problems over time since injury as a function of Group Membership and Parental Scaffolding during the Free Play Condition (low vs. high)

Table 1**Participant Characteristics by Injury Group**

	Severe TBI (<i>n</i> = 20)	Moderate TBI (<i>n</i> = 52)	OI (<i>n</i> = 95)	Difference <i>p</i> < .05
Age at injury (years)	4.98 (0.94)	4.97 (1.20)	5.08 (1.08)	<i>ns</i>
GCS score	3.95 (1.79)	13.40 (2.07)		Sev < Mod
Days in hospital	10.54 (20.28)	3.02 (4.50)	1.32 (1.01)	Sev > Mod; Sev > OI
ISS	12.94 (8.61)	15.35 (8.15)	6.99 (2.69)	Sev > OI; Mod > OI
IQ at baseline	83.56 (15.85)	98.10 (16.14)	102.81 (14.67)	Sev < Mod; Sev < OI
Boys <i>n</i> (%)	13 (65.0)	33 (63.5)	51 (53.7)	<i>ns</i>
Race <i>n</i> (%)				
White	14 (70.0)	37 (71.2)	74 (77.9)	<i>ns</i>
African American	5 (25.0)	9 (17.3)	14 (14.7)	
Mixed/other	1 (5.0)	6(11.5)	7 (7.4)	
Maternal education, high school <i>n</i> (%)	14 (70.0)	46 (88.5)	90 (94.7)	Sev < OI
Income	\$ 53,766 (17,079)	\$61,576 (23,974)	\$65,287 (23,409)	<i>ns</i>

Notes. Values are presented as M (SD) unless otherwise specified. Income was based on the median income for the individual's census tract based on the most recent available census data. TBI = traumatic brain injury; Sev = severe TBI; Mod = complicated mild/moderate TBI; OI = orthopedic injury; GCS = Glasgow Coma Scale score (Teasdale & Jennett, 1974); ISS = injury severity score; IQ = intelligence quotient.

Table 2

Correlations Among Parent Behaviors Across Time Points by Condition

	1	2	3	4	5	6	7	8	9	10	11	12
1. Warmth during free play	--											
2. Warmth during structured task	.65**	--										
3. Contingent responsiveness during free play	.80**	.64**	--									
4. Contingent responsiveness during structured task	.55**	.85**	.67**	--								
5. Negativity during free play	-.32**	-.28**	-.34**	-.34**	--							
6. Negativity during structured task	-.20*	-.28**	-.26**	-.33**	.42**	--						
7. Directives during free play	-.21**	-.10	-.18*	-.13	.08	-.08	--					
8. Directives during structured task	-.20*	-.29**	-.18*	-.27**	.15	.17*	.28**	--				
9. Scaffolds during free play	.41**	.31**	.40**	.34**	-.27**	-.29**	-.76**	-.39**	--			
10. Scaffolds during structured task	.27**	.45**	.27**	.47**	-.22**	-.36**	-.27**	-.81**	.51**	--		
11. Restrictive behaviors during free play	-.31**	-.32**	-.34**	-.32**	.29**	.32**	-.28**	.18*	-.42**	-.38**	--	
12. Restrictive behaviors during structured task	-.16*	-.34**	-.19*	-.40**	.16*	.35**	.04	-.12	-.29**	-.48**	.38**	--

Note.

* $p < .05$;** $p < .01$

Table 3
Correlations of Child Behaviors with Parent Behaviors by Time Point by Condition

	Parent Warmth	Parent Contingent Responsiveness	Parent Negativity	Parent Directiveness	Parent Scaffolds	Parent Restrictive Behaviors
Condition: Free Play						
Baseline Child Warmth	.43**	.40**	-.09	-.18*	.22**	-.07
6 mos Child Warmth	.48**	.44**	-.04	-.22**	.24**	-.06
12 mos Child Warmth	.51**	.60**	-.15	-.31**	.26**	.04
Condition: Structured Task						
Baseline Child Cooperation	.15	.27**	-.29**	-.10	.34**	-.42**
6 mos Child Cooperation	.06	.16	-.25**	-.11	.16*	-.11
12 mos Child Cooperation	.07	.12	-.18*	-.21*	.29**	-.19*
Baseline Child Behavioral Dysregulation	.26**	.30**	-.22**	-.13	.37**	-.43**
6 mos Child Behavioral Dysregulation	.22**	.23**	-.40**	-.06*	.20*	-.29**
12 mos Child Behavioral Dysregulation	-.06	.03	-.20*	-.04	.18*	-.27**

Note.

* $p < .05$;

** $p < .01$

Table 4

Percentage of Participants Above Clinical Cutoff

Variable	Baseline			6 months			12 months			18 months		
	Severe TBI (<i>n</i> = 18)	Moderate TBI (<i>n</i> = 54)	OI (<i>n</i> = 95)	Severe TBI (<i>n</i> = 16)	Moderate TBI (<i>n</i> = 49)	OI (<i>n</i> = 94)	Severe TBI (<i>n</i> = 17)	Moderate TBI (<i>n</i> = 50)	OI (<i>n</i> = 83)	Severe TBI (<i>n</i> = 18)	Moderate TBI (<i>n</i> = 48)	OI (<i>n</i> = 84)
CBCL Internalizing Problems <i>T</i> score	27.78	11.11	8.42	37.50	12.24	5.32**	23.53	6.00	4.82*	27.78	4.17	4.76*
CBCL Externalizing Problems <i>T</i> score	22.22	9.26	8.42	50.00	16.33	6.38***	47.06	8.00	4.82***	33.33	12.50	4.76**
CBCL ADHD <i>T</i> score	16.67	9.26	8.42	37.50	14.29	7.45*	47.06	10.00	7.23***	27.78	14.58	8.33

Notes: Clinical cutoff at $T = 63$.

CBCL = Child Behavior Checklist; OI = orthopedic injury.

* $p < .05$.** $p < .001$.*** $p < .0001$.

Table 5**Final Models with Significant Moderation**

Effect	Estimate	Standard Error	Df	F	p
Warm responsiveness during structured task and ADHD symptoms					
Pre-injury ADHD symptoms	0.66	0.05	1, 251	163.58	< .001
Parent psychological distress (BSI-GSI)	0.16	0.05	1, 251	10.37	.002
Age at injury	0.09	0.06	1, 251	2.16	.143
CBCL version	0.03	0.09	1, 251	0.09	.769
Group			2, 251	3.46	.033
Time since injury	−0.05	0.08	1, 251	0.05	.830
Warm responsiveness	0.02	0.09	1, 251	5.53	.019
Group x time since injury			2, 251	0.10	.909
Group x warm responsiveness			2, 251	4.17	.017
Warm responsiveness x time since injury	0.00	0.08	1, 251	5.42	.021
Group x warm responsiveness x time since injury			2, 251	3.25	.041
Warm responsiveness during free play and ADHD symptoms					
Pre-injury ADHD symptoms	0.65	0.05	1, 253	164.87	< .001
Parent psychological distress (BSI-GSI)	0.15	0.05	1, 253	9.90	.002
Age at injury	0.09	0.06	1, 253	2.22	.137
CBCL version	0.05	0.09	1, 253	0.26	.607
Group			2, 253	11.65	< .001
Time since injury	−0.04	0.06	1, 253	0.44	.508
Warm responsiveness	0.02	0.04	1, 253	5.15	.024
Group x warm responsiveness			2, 253	3.09	.047
Scaffolds during structured free play and internalizing symptoms					
Pre-injury internalizing symptoms	0.60	0.05	1, 248	154.22	< .001
Parent psychological distress (BSI-GSI)	0.21	0.05	1, 248	17.99	< .001
Age at injury	−0.01	0.06	1, 248	0.03	.866
CBCL version	−0.13	0.10	1, 248	1.62	.205

Effect	Estimate	Standard Error	Df	F	p
Group			2, 248	0.24	.786
Time since injury	−0.16	0.09	1, 248	0.04	.837
Scaffolds	−0.23	0.11	1, 248	5.75	.017
Group x time since injury			2, 248	1.52	.221
Group x Scaffolds			2, 248	5.48	.005
Scaffolds x time since injury	0.14	0.09	1, 248	5.36	.021
Group x Scaffolds x time since injury			2, 248	5.88	.003

Note. BSI-GSI = Brief Symptom Inventory-Global Severity Index; CBCL = Child Behavior Checklist